Southeastern Iowa, its distribution, aspects, fossils and deposition. The author accepts the theory of lacustrine origin.

WITTER, F. M.—*Notes on the Loess*. From the Muscatine Tribune (1879).

This is the title of a paper read before the Muscatine Academy of Science, February 10, 1879. It contains a general discussion of the Iowa loess, with incidental references to the same deposit in Nebraska and Missouri. Lists fossils from various localities in Iowa. "Entire absence of the families of Unionidæ and Viviparidæ in the loess" of various parts of the State is noted and commented on. Concludes in favor of the aqueous origin.[1]

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ORGANIC PHYSICS.

BY CHARLES MORRIS.

(Continued from June number.)

IN the life history of the Metazoa, or many-celled animals, the products of cell division enter into a new relation. Instead of the new cells existing as separate, they exist as united individuals. But there is nothing to show that they otherwise differ in any essential respect from the results of Protozoan division. The germ still separates into its constituents, which become more and more polarly diverse, until a vast mass of new cells is produced, in which those with male excess of vigor are just equal to those with female excess.

But in this development of a matured body from its germ, several interesting features appear, which we must successively consider. The first of these is the separation of the body into two bilaterally similar halves, a result which, although partly or completely masked in the lowest classes of the Metazoa, is very distinctly declared in the higher classes. Under our hypothesis this separation of the body into two similar halves has a special significance. The two halves of the body are polarly distinct, being respectively male and female in chemical constitution, so that the body of the offspring represents that of both its parents.

This conclusion seems to necessarily arise. If the simplest animal cell be a polar organization, with acid and basic, or male and female poles, then its division is a sexual separation. If the two new cells continued to cohere, they would form a bilaterally

[1] In connection with these references information of much value and direct bearing may be found in an article by Professor J. D. Whitney on "The Chinese Loess Puzzle" in AM. NAT., Vol. XI, pp. 705–713, in which the author inclines to the subaërial hypothesis. See also the reports of the geological surveys of Illinois, Ohio, Indiana and Michigan.

symmetrical organism, with a male and female side. Such may be the result of division of the germ of the higher animal. Produced by the union of male and female cells, and thus being sexually balanced, its first step of division is into two cellular halves, respectively male and female in their excess energies. Each of these continues to divide, and we can, with some show of reason, believe that each is the foundation of a separate development, which results in two complete organisms, intimately connected across their median line, yet polarly distinct.

Such is a not illogical deduction. The male and female constituents being polarly separated in the germ, and in the primary results of its division, might naturally continue polarly separated in the ultimate results of its division. The mature body consists of two halves, answering organ for organ, and so intimately connected by communicating nerves that practically no separation exists. The lateral halves of the body are as like and as intimately combined as were the lateral halves of the germinal cell, and the mature state is only a complete unfoldment of conditions which existed undeveloped in the germ.[1]

Had we space, several significant facts might be brought in illustration of this idea. The character of these illustrative facts may be briefly described. The frequent difference in degree of development of the two sides of the body, is indicative of differences of vigor in the germinal poles, the male or the female pole having an excess of energy. Certain malformations of the body are strongly indicative of such a relation of its opposite halves. In that form of malformation in which clefts or fissures appear, this takes place invariably in the median line of the body. What is called hare-lip is one such case of fissure, but many diverse cases have been observed, and they are all of one general character, a lack of continuity in the median line of the body, as if its two halves had failed to fully unite. In another kind of malformation, in which lack of development produces coalescence of organs, this always takes place across the median line. Thus cases are known in which the two eyes were merged into one, and others in which the lower part of the face was so undeveloped

[1] Each half of the body is, in fact, under the direct control of the other half, since the nerve center of each half is connected with, not its own organs, but those of the other half. This peculiar relation between the nerve centers and the lateral halves of the body is a fact of considerable significance in this connection.

that the two ears became conjoined. Similar coalescence has affected the viscera and the lower part of the body, but there is no instance of a coalescence that has not equally affected both sides.

In malformations in which some part of the body is abnormally developed, the rule is the same, the abnormality always extends across the median line. It is very rare that there appears any marked excess or deficiency of one side that is not shared by the other, and we know of no case of such lateral excess or deficiency sufficiently marked to be considered a monstrosity, though slight differences are of very usual occurrence.

There is another abnormality of great significance in this connection, that of hermaphroditism. In every case of true hermaphroditism in the higher animals, the male and female organs of generation occur on opposite sides of the body. This is not usually the case in the normally hermaphroditic animals, in which the two organs are often combined in a single gland, but so far as it goes it is an indication of sexual difference of the two halves of the body.

And such a conception aids us in comprehending the results of hermaphroditic generation. For if the two sides of the body are thus related, germs coming from opposite sides might be capable of proliferation, and thus unisexual generation be a normal process.

In the development of plants there does not, at first sight, seem to be any trace of bilateral division. And yet if we consider that the active layer of plants is a cylindrical tissue, bounded internally and externally by the most vital layers of the wood, we may surmise that the polar halves of the plant consist of its internal and external active layers, between which flows the nutrient fluid, in a cylindrical vascular tissue. This idea is sustained by the position of the hermaphroditic organs of the plant, the female organ always being central and the male organs disposed in a circle around it.

Evidently, under such a sexual law as that here proposed, there might be great differences in the sexual energy, and also in the life energy of new individuals. Where the polar energies of the germ were weak, the life energy would be reduced. And the degree of sexual differentiation would depend upon the excess of energy of one sexual pole over the other. Strength or weakness

of special tissues might result from the same cause, an excess or lack of polar energy in the chemical constituents of the germ which give rise to these tissues.

We have so far considered protoplasm as consisting of molecules of similar chemical constitution, and differing only in acid or basic energy. But in the protoplasm of the higher animals a special chemical differentiation takes place. The molecules of the unit of each tissue have a special chemical constitution of their own, which differs from that of any other tissue.

The simplest organisms have, in all their parts, identical relations with the environment. But as development goes on, this identity of relations ceases to exist. Fixed duties are assigned to fixed parts of the body, until finally every region of the organism has its definite office to fulfill. Chemical variation necessarily accompanies this functional variation. The special duties given to special tissues are chemical duties, or motor duties dependant upon chemical action. For their proper performance each tissue must have a special chemical constitution. Such a chemical divergence is a necessary result of divergent relations with the environment. In the higher animals all the internal tissues are removed from contact with external conditions. Their environment is the nutrient fluid. But this differs in different parts of its course. Certain organs take certain elements from it. More internal organs must employ as nutriment other material for which they may have a less vigorous affinity. But this assimilation of varied nutriment produces a divergence in chemical constitution, so that each tissue finally accepts from choice what it first may have accepted from necessity. This process of differentiation has gone steadily on, from the first to the last step of organic development, every change in the environment of a tissue producing a change in its chemical organization.

If such be the case we should look upon functional variation not as causing but as caused by chemical specialization. Many circumstances, having that undetermined origin which is called chance, may produce variations in the relations of the tissues to the external or the internal environment. In consequence, their chemical character changes. As a secondary result of this change their organic function varies. A new and perhaps more diverse relation is established between the parts of the organism in consequence of specializations in its chemical constitution, arising

from specialized relations with the environment. By a continuance of this process all functional differentiation is produced. Thus organic development is primarily chemical specialization.

One necessary result springs from this form of differentiation. Unspecialized cells may exist independently. All specialized cells must be coherent. They owe their existence to conditions produced by the action of other cells, and therefore can only exist in intimate connection with those cells. Thus chemical specialization is necessarily followed by cellular coherence, and the production of many-celled organisms. It is the basic cause of all life evolution beyond the Protozoan.

The considerations here taken render necessary certain underlying laws of organic evolution. Variation in the environment necessitates chemical specialization, followed by coherence of cells and functional differentiation. But a yet more primary principle lies at the basis of evolution. If the simplest life form depends for its vital energy upon chemical polarity, then an essential step to evolution must be some means of increasing the vigor of this polarity. Organic forms may have begun in colloid units with very feeble polar differentiation. If so, the first step in the evolution process must have been an increase of this differentiation, so as to increase the growth vigor and the power of germinal reproduction, or cell division. The tendency of such units is to neutralization, through chemical satisfaction. Oxidation overcomes this tendency by reproducing the original polarity. May not oxidation do more than this, and in some cases yield an increased polarity? If so, organic evolution resolves itself into this. Primarily the life energy of organisms grows greater and greater, as continued oxidation yields a slowly increasing vigor of chemical polarity. Secondarily the life energy becomes more diverse as successively new relations with the environment arise, and new chemical specializations in consequence. As oxidation produces the one, activity aids the other, the active organism varying its relations much more rapidly than the passive one.

If such be the chemical character of the mature organism, what is most probably the chemical character of the germ from which it arises? If in the process of growth only chemical agencies are active, and only chemical results produced; if chemical affinity is alone concerned in the two processes of physical growth and organic differentiation, then the germ can need none

but chemical powers, and all the physical actualities of the body must exist as chemical possibilities in its germ. The germ must represent, not physically but chemically, the fully developed organism.

If such be the case the molecules of the germ must be adapted to develop, by chemical assimilation, not only into every tissue of the body, but into every special portion of every tissue. Every region must be potentially present in the germ, each molecule of which must have its special polarities, and be adapted to a special mode of development.

Molecules are not produced by a "fortuitous concourse of atoms." Complex molecules are built up by successive steps of synthesis, and the mode of arrangement of the atoms is more important than their numbers and kinds. Even slight changes in this particular may cause marked changes in the physical character of the molecule.

The energies of the molecule are solely those of affinity. Two molecules of different formation differ in their chemical polarities, and their relations with exterior matter depend strictly upon the character of these polarities. Oxygen and hydrogen atoms unite to form a polar molecule of water. A number of water molecules combine with carbon to form a polar molecule of starch or sugar. This may in some way combine with ammonia to form a nitrogenized molecule. And so, perhaps by many steps of synthesis, the most complex molecule is finally attained. But in the formation of the final and of every intermediate molecule, an undeviating chemical principle must be obeyed. Each must be composed of acid and basic, or positive and negative constituents, and thus be a chemically polar organism. Thus it will be polar not only as a final compound, but each of its constituent molecules, down to the lowest of all, will also be a polar compound. And each minor polarity in the mass will retain its special character intact, and must manifest its peculiar affinities should it be set free by disintegration.

Instead of considering the polarities of constituent molecules, we may approach the subject from another direction. An organic being, a man for instance, is a vast mass of chemical molecules, aggregated primarily into cells, and secondarily into variously divergent tissues. The physical characters of these tissues depend on the chemical affinities and polarities of the cells com-

posing them, and these again upon those of their molecules. A greatly dwarfed being would have the same organization but must be composed of a vastly decreased number of cells and molecules. Yet dwarfing might continue until a very minute being resulted, so greatly reduced in size that the tissues would be represented by cells only. In such a case specialization would have become generalization, the cells which replace the tissues being adapted to reproduce these tissues if growth again take place. But if the dwarfing process still continue, the cells must disappear, and the nuclear bases of the cells, or minute groups of the nuclear molecules, replace them. But such nuclei, or groups of molecules would probably aggregate to the formation of cells of heterogeneous instead of homogeneous molecular constitution. Such seems a probable result of a continued dwarfing of a mature being. It begins with an aggregation of diverse and homogeneous tissues, specially arranged. It yields, if continued far enough, an aggregation of homogeneous cells, representing in character and arrangement the tissues. If continued still farther it yields an aggregation of heterogeneous cells, whose molecules represent in character and arrangement the homogeneous cells above mentioned. Each such cell would be a potential representative of a group of tissues. But if the dwarfing process be still continued, these generalized cells must also be reduced to groups of molecules, which would aggregate to form fewer and still more generalized cells. And a final completion of the dwarfing process would be a single cell, representing potentially the whole body. Such a germinal cell must contain molecules so constituted and arranged, that in their development each molecule, or each homogeneous group, will yield homogeneous cells, arranged as their molecules were arranged in the germ. And a final development of these cells must yield the special tissues which they are adapted to form.

Thus by dwarfing the body to microscopic dimensions, or until it be reduced to a single cell, this cell must represent in its molecular organization the physical organization of the whole body. Its molecules must possess the special polarities of the tissues, and be arranged as the tissues were arranged. And the interaction of the molecular polarities, must render this arrangement as necessary in the germ as the physical duty of the tissues renders it in the mature organism.

It might be imagined that such a germ would be greatly diversified in the character of its molecules. Yet no such necessity exists. The divergence from homogeneity in these molecules would probably be very slight. For diverse as are the physical characters of separate tissues, it is improbable that they vary greatly in chemical character. The protoplasmic bases of all the tissues are perhaps nearly homogeneous, minute differences in their chemical constitution, and in their polar affinities, yielding the wide divergence in the physical characters of the tissues.

The physical analysis of a tree yields us striking evidence on this point. Here we find solidified woody fibers; there vascular tubes of varied form; here gum, there cork, there mucilage; here at least two varieties of starch; in the sap dissolved sugar; in the flower and fruit, liquid or solidified sugar, of several varieties. In these diverse tissues we have almost all the material of the tree. Yet when we come to examine them chemically we find them to be nearly the same thing. They are all composed of carbon with slightly different equivalents of water. And if the divergent tissues have but this slight chemical difference, how much less may be the differences in the protoplasmic nuclei to whose chemical activity they are due?

It is probable, therefore, that the protoplasm of the varied animal tissues has but minute differences in its chemical constitution, these minute differences being capable of yielding marked divergences in the physical results of their action. And the germ, which must contain molecules derived from every portion of the body, may be a nearly homogeneous mass of protoplasm, the minutest differences in its molecules being capable of yielding marked differences in the tissues arising from them.

The marvelously intricate germ of the human body is not produced but once, or but a few times. It is, on the contrary, continually produced, as if the body was incessantly employed in forming such minute and generalized copies of itself. For such a continual reproduction there must be some important physiological agency constantly affecting every tissue, or perhaps every cell of the body, so that these tissues, in addition to their ordinary duty, perform an unceasing generative labor. They are adapted to work not only for the needs of the single individual to which they belong, but for a possibly great number of future individuals, since, could the germs produced by each individual

develop, it might yield myriads of mature offspring. For such an important and continued function, provision must be made, and this provision must exist in some duty naturally arising from the chemical and organized constitution of the body.

Efforts have been made to explain this phenomenon, of which the most notable are those of Spencer and Darwin. Spencer advances a hypothesis of physiological units, in some way intermediate between the molecular and the cellular units of the body, and being in themselves generalized copies of the body. He does not think it possible that this generalism can exist in the molecules themselves.

The hypothesis advanced by Darwin is more satisfactory, though equally without visible support. He proposes the idea that every portion of the body is constantly throwing off invisible gemmules of excessive minuteness, some arising from the body itself, some brought into it from ancestral bodies. These gemmules, he thinks, contain the special characteristics of the part from which they arise, pass into the blood current, multiply by self division, and finally aggregate into a reproductive germ, whose development may reproduce the parent organism and, to some extent, that of more remote ancestors.

This pangenesis hypothesis approaches a physical explanation of the difficulty, although it seems in certain respects insufficient. In fact, no such hypothesis may be needed. If the body is engaged in so incessant a labor we might reasonably expect to discover some visible evidence of such an important function. And certainly a very cursory examination of the body yields us evidence which seems to offer a satisfactory solution of this difficult problem. It may seem strange if we assert that every portion of every tissue is constantly giving off, or in some way influencing the formation of organized substance; that this substance is not invisible, like the pangenetic gemmules, but perfectly visible; that it has no discoverable office in the body, and that its organization is that of a fully vitalized germ.

Yet such a material does exist, and is that known as the leucocyte, or the white blood corpuscle. The office of this corpuscle has been, and still is, a puzzle to physiologists. They suppose that it may be converted into the red blood corpuscle, yet this remains a supposition only. If we closely examine the origin and character of the leucocytes we may feel warranted in ascrib-

ing to them another duty and destiny. These corpuscles exist abundantly in the blood, but they also exist in equal abundance in the lymph, from which the blood seems to derive them. It is known that they arise independently in the lymph, and in any exuded blastema in contact with a living surface, as in the fluid of pus cavities.

But the lymph is a liquid which exists in direct contact with perhaps every cell of every active tissue of the body. It apparently originates in a nutrient fluid which exudes from the blood through the walls of the vessels. It bathes and yields nutriment to the active cells, and carries off their waste materials. And it seemingly carries off more than this, for the white corpuscles make their appearance in the most interior lymphatic channels, anterior to the lymphatic glands. Thus they arise in the blastema in direct contact with every portion of every tissue, and are possibly formed under the direct influence of the tissues in which they appear, if they are not indeed exuded and vital portions of the living tissues.

Their increased numbers in the lymph as it approaches the blood indicates a continued life action, a division resembling that of the individual Protozoan. In fact the whole behavior of these corpuscles significantly reminds us of that of the lower Protozoa. If existing outside the body, they would be taken for individual Amœbæ, for they are in organization and behavior indistinguishable from the lowly organized animal known as the Amœba. They constantly advance and retract pseudopodia, which process constitutes the amœboid life function, and are, like the Amœbæ, composed of a nucleated mass of protoplasm. Thus they in every respect simulate the lower Protozoa.

If the white blood corpuscles increase in numbers by division, as seems evident, they must also assimilate nutriment and grow. The constant change of form of the Amœbæ is a nutrient function, and it must have the same significance in the white corpuscles. In fact, we have direct evidence of this. They have been proved by the addition of coloring matter to their containing fluid, to absorb material from this fluid, retain it for a while, and then reject the innutritious colored granules.

There is only one function wanting to complete the whole cycle of Protozoan life, that of conjugation, or sexual union. This has not been shown to occur in the case of the leucocytes. But there

is no reason to conclude that it does not occur, and it is by no means improbable that their nutrient process consists, partly at least, in an assimilation of the molecules, or the budded gemmules, of other leucocytes.

With these preliminaries we may proceed to consider the hypothesis that the leucocytes are the true germinal particles, which embrace in their organization the chemical and physical characteristics of every region of the body, this generalism of constitution being produced by successive combinations of the leucocytes, until they finally produce composite germs which are true generalized copies of the whole body.

From this point of view the hypothesis which looks upon the animal body as a colony of individual cells may not be an untrue one. Each cell depends for its individual life upon the nutrient pabulum elaborated for it by the combined labor of all the other cells of the body. It does not go forth as an individual in search of food, for its proper food is brought to it. But though fixed in position, its individual life resembles that of the Protozoan. It assimilates food, grows, and divides into new cells. And it is quite possible that all these cells do not remain united. Some of them may be thrown off into the lymphatic fluid which bathes the mother-cell. Each cell may thus, in addition to its coherent offspring, send off independent offspring, to wander out into the world at large of the nutrient fluid.

Thus from every cell of the body may come wandering offspring, each a perfect copy of the mother-cell. The inducement to their being thrown off may be the better chances for nutrition offered by a free existence in the nutrient fluid. It is one phase of the struggle for existence and adaptation to circumstances, which displays itself everywhere in nature, from its lowest to its highest conditions. Possibly each cellular unit of the body performs a double duty. It acts both as a constituent part of the body and as a free individual. In its former office some of its daughter-cells remain coherent, and aid in the growth of the tissues. In its latter office some of its daughter-cells are budded off into the surrounding fluid to pursue an individual life of their own. In this respect it reproduces the Protozoan mode of life, in which all new cells are budded off into the surrounding fluid as separate individuals.

Such a process is not improbable in itself. We can with some

justice look upon the cells as individuals, and as, in their methods of development, concerned only for their own private interests. In the Protozoa the new cells are all set free because there is no advantage to be gained by their remaining coherent. In the Metazoa there is an advantage to be gained by coherence. They are adapted to a special nutriment, which is brought to them, and which they would fail to obtain unless united into a specialized organism. But the nutrient fluid from which they derive food, offers also a sphere of advantageous free existence. The cells are equally well situated when free as when coherent, and therefore the newly-formed cells are as likely to become free as to remain coherent. Possibly they have a somewhat better chance for life in the free state, as they are surrounded by a nutrient fluid exactly suited to their needs. Hence the free buds rapidly develop into actively vital cells, yielding what are known as the lymph corpuscles.

But these corpuscles are contained in a moving fluid. They are quickly borne away from their point of origin and thrown into the blood. Here the conditions for their free life are less favorable. They may fail to obtain the specially elaborated nutriment to which they are adapted, and thus may lose their vitality and possibly become modified into the red blood corpuscles.

The struggle for existence may be active between the leucocytes in the blood. Beale and Max Schultze describe minute globules in the blood which they suppose to be fragments (or gemmules) budded off from the white corpuscles. These may serve as nutriment to other corpuscles. If so the corpuscles must gradually acquire molecular conditions arising from varied regions of the body, and thus become more generalized in constitution and better adapted to the nutrient conditions of the blood. Possibly a considerable degree of generalization may be attained in this manner.

This process of cellular budding and the formation of free cells, is continuous throughout life. It has its phases of variation in the daily life of organisms. The leucocytes appear more abundantly after meals, and decrease in number during abstinence. But the nutrient and developing activity of the cells must display this same variation. Possibly the process of free budding may be more active in mature life than in youth. The rapidity of growth in youth indicates a strong tendency to coherence of cells,

though perhaps the more vigorous assimilative energy at that period of life may render both the coherent and the free cell formation very active. In mature life the cessation of growth seems to indicate a loss of the coherent energy. The great mass of the new cells are perhaps budded out as free individuals into the lymph, while only enough remain coherent to keep up the integrity of the tissues. In old age even this fails, and the body shrinks. It is becoming disintegrated by the growing preponderance of free over coherent cell formation. It is not improbable that the increasing thickness and density of the tissues may have some influence upon this result. Nutriment reaches them less readily, and the new cells are more advantageously situated in the free than in the coherent state.

Thus the independent life of the cells becomes, as life goes on, less and less subordinated to the needs of the body. Each coherent cell buds off minute gemmules, or organic units, which quickly assimilate nutriment from the rich plasma surrounding them, and grow into amœboid cells. These buds may be, in many cases, very minute, for corpuscles will arise in an apparently homogeneous blastema. Some writers argue that this blastema is structureless, but it is not easy to credit that it is destitute of the germs of organized structure. These may be excessively minute masses of molecules, invisible gemmules derived from the tissues, but they must be present as centers and controlling agents of the organized corpuscles which quickly appear. We are, therefore, forced to believe that the colony of coherent cells which forms the body as a whole, gives rise to a colony of free individuals, which swim off and develop in the surrounding fluid, precisely as the budded offspring of a lowly organized animal float away to develop as independent individuals. The body continues to absorb nutriment, but the products of its nutrition flow away and resolve themselves into a swimming colony of single-celled organisms. Cessation of individual life becomes necessary from the increasing tendency of the body to resolve itself into its elements.

If now we hastily review the process of reproduction throughout the range of animal life, we shall find it to favor the hypothesis here proposed. Everywhere there seems a struggle between the opposite tendencies of new germs to remain coherent and to become independent. The result undoubtedly strictly depends

upon the advantage in nutrient relations between the free and the coherent state. In the simplest organisms the new cells remain free. They would derive no advantage from coherence with the mother-cell, and they are fully capable of continuing the species, since they contain all the molecular conditions of the type. Here there is no growth, the whole life process is a reproductive one. In less simplified forms, such as the Foraminifera, both tendencies are displayed. Possibly the armored condition of the type renders it advantageous for coherence to continue up to a certain stage, yet independent cells are incessantly budded off. In the highest Protozoa a molecular differentiation seems to arise between the different parts of the single celled organism, and this is probably the primitive stage of the cellular differentiation in the Metazoa. The special molecules of the Infusorian represent the special cells of the Metazoan. In the latter type of animal a considerable degree of coherence becomes absolutely necessary, yet it is probable that in the lower forms free cell formation is very active. There are two purposes to be subserved in the organism, the continuance of individual life and the reproduction of the species. For the one, cell coherence is necessary. For the other, cell freedom. And both of these are favored by the nutrient conditions. The specialized nutriment bathes the cells, and the new cell products can gain nutrition both as coherent and as free cells. But the process of reproduction is not as simple as in the Protozoa. No longer does every portion of the body represent the whole body. The free buds thrown off by the cells into the nutrient fluid represent only a special section of the body. Only by some process of combination can cells be produced containing the molecular constituents of the whole body. And it is probable that this combination is a natural resultant of food assimilation by these free cells. They take in nutriment, grow, divide or bud off minute gemmules, and these gemmules are taken up as nutriment by other cells. Thus fully generalized cells are produced, capable of existence outside the body, and adapted to develop into a copy of the parent organism.

As the animal becomes of higher grade the process of tissue formation preponderates over that of germ formation, the number of developing germs decreases and the resolution of the body into its offspring becomes less declared. From being total it becomes partial. In fact, as specialization increases the combina-

tion of the cell germs is not so readily achieved, while it becomes necessary for the reproductive germ to be provided by the parent organism with suitable food for its first stage of development. In the most advanced stage of this process the germ must be retained and develop within the parent organism until its specialization has become nearly complete. This necessity adds to the importance of individual life. Where the germs ask no further aid from the parents, the latter cease to exist, all their strength going into the germs. Where the germs ask considerable aid from the parents, the latter must retain much of their vital strength, and cannot completely disappear in their offspring. Where, as in man, the offspring is fully developed through parental aid, the life vigor of the parent cannot be exhausted by that of its offspring, particularly as the continuance of the species needs long continued successive production of offspring. The vital strength necessary for this purpose only slowly declines, and continues long after the period of child-bearing is past.

Thus there is a gradual advance from the condition in which all new cellular individuals become free, to that in which the greater number of new individuals remain coherent. Where the organic specialization is slight, the cells are more likely to be budded off into the free state than to remain coherent. In such organisms the reproductive power is great. Countless buds are thrown off by the cells of the tissues. The aggregation of a few of these suffices to yield a cell containing all the molecular conditions of the parent form. Thus reproduction is specially vigorous, and the life of the race greatly preponderates over that of the individual. As specialization increases, this process is gradually checked. Growth power gains upon reproductive power; the life of the individual upon that of the race. Gemmules may be budded off into the nutrient fluid as freely as before, but fewer of them attain full generalization, as this process is a much more complex one. And those which fail to do so are probably reconsumed by the body as nutriment, and go to aid the growth process.

(To be continued)